SEVRENS

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FRUIT JELLY INVESTIGATIONS

By

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CONTENTS

SECTION I

INTRODUCTION

Scope of the Paper

For the formation of a fruit jelly proper proportions of three ingredients, acid, pectin, and sugar are necessary. Since these are not normally found in fruits, the problem of jelly-making rests with the proper adjustment of these three factors. It is the purpose of this investigation to determine the amount of each ingredient that is necessary to add to various fruit juices to obtain the best jelly.

It is a further purpose of the paper to develop some simple laboratory experiments involving the factors of jelly formation. Four experiments have been developed which are suitable for inclusion in the laboratory work of organic chemistry.

Throughout the discussion special attention has been paid to the degree of acidity or pH value of the fruit juices used, because it appears to be the factor which needs the most careful adjustment if best results are secured.

Meaning of pH

Previously it was the custom to denote a solution as strongly acid, slightly acid, neutral, slightly alkaline, strongly alkaline. Such terms are at best very indefinite and the pH scale was invented to provide a means of stating definitely the degree of acidity or alkalinity of a solution.

Since the hydrogen-ion (H^+) is the factor which gives to a solution its active acidity, the concentration of hydrogen-ion in a solution may be used as a measure of the acidity. Such figures as we would encounter would be extremely cumbersome so the pH scale is used in which the pH value represents the logarithm of the reciprocal of the concentration of hydrogen-ion. In pure water the concentration of H^+ has been found to be 1/10,000,000 gram ion of hydrogen per liter. The reciprocal of this number would be 10,000,000 and the subsequent logarithm would be 7. Since the concentration of H^+ and OH^- in pure water are equal, therefore the solution is neutral. pH 7

then is taken as the neutral point, any values below 7 are acidic, those above are alkaline. This can readily be seen, for suppose a solution instead of containing 1/10,000,000 gram ion of hydrogen per liter contains 1/10,000 gram ion of hydrogen (a far greater concentration) the reciprocal then would be 10,000 and the logarithm 4.

pH Scale

--14	
--13	
--12	
--11	---alkaline values
--10	
--9	
--8	
--7	--------neutral
--6	
--5	
--4	
--3	---acid values
--2	
--1	
--0	

Each unit in the scale represents a ten-fold change in the concentration of hydrogen-ion.

Let it be understood that in alkaline solutions, hydrogen-ions are not absent, but the

concentration is simply less than that of hydroxyl ions. In any water solution the product of the concentrations of H^+ and OH^- is always 10^{-14}. As previously stated, in pure water the concentrations of H^+ and OH^- are equal. If by the addition of acid, the concentration of H^+ is increased, then the concentration of OH^- must be correspondingly decreased. Conversely, the addition of a base furnishing OH^- must bring about a corresponding decrease in the concentration of H^+.

Methods of Determining pH

There are two methods of determining the pH value of a solution, electrometric and colorimetric.

In the electrometric method, comparison of the unknown solution is made with a normal hydrogen electrode whose electrode potential is called zero. The pH is calculated from the equation: $pH = \dfrac{E_h}{-\ 0.000,198,322\ T}$ (1) in which E_h is the

(1) Clark: The Determination of Hydrogen Ions
The Williams and Williams Co. 1928 p. 224

potential of the unknown solution with reference to the normal hydrogen electrode; T = absolute temperature ($273.1 + t^{o}C$).

The colorimetric method has been so simplified that it is now by far the easiest, most rapid and most economical method of determining pH. In colorimetric determinations use is made of the fact that certain substances called indicators change color with changes of acidity or alkalinity. These indicators are weak organic acids, the best known of which is litmus. However, the familiar test of litmus, red in acid and blue in alkaline solutions covers too wide a range to be of any use in accurate determinations.

Clark gives a list of nearly two hundred indicators (2) and their useful range, that is, the section of the pH scale over which distinct color change takes place with a slight change in the hydrogen-ion concentration. Of this list

(2) Clark: The Determination of Hydrogen Ions
The Williams & Williams Co. 1928 p. 76

potential of the hydrogen electrode with reference to the normal hydrogen electrode, T = absolute temperature (273.1 + t°C).

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Clark gives a list of [illegible] common indicators[1] [illegible] [illegible] the useful range [illegible] [illegible] [illegible] [illegible] [illegible] the hydrogen ion concentration, [illegible]

(1) Clark: The Determination of Hydrogen Ions. The Williams & Wilkins Co., 1928 p.72

four are adequate for the pH determinations carried out in this investigation.

Meta Cresol Purple------pH 1.2-2.8

Brom Phenol Blue--------pH 3.0-4.6

Brom Cresol Green-------pH 3.8-5.4

Brom Cresol Purple------pH 5.2-6.8

Stock solutions of the indicator are made by preparing usually a 0.04 per cent solution with distilled water.

Color charts are available which show the color changes of these indicators for each 0.2 unit change in pH. To determine the pH value of an unknown solution, therefore, one has only to take in a test tube a portion of the solution to be tested, add a given amount of indicator (0.5 cc of indicator solution to 10 cc of unknown solution) and compare the result with the color chart. While this method is satisfactory with clear and colorless solutions it can not be used with those that are turbid or have color which would mask the color of the indicator.

For turbid and colored solutions, color

These are the ranges for the pH determinations carried out in this investigation.

Brom Cresol Purple ----- [illegible].

Brom Phenol Blue --------pH 3.0-4.6.

Brom Cresol Green ----pH 3.8-5.4.

Brom Thymol Blue---pH 6.0-7.6.

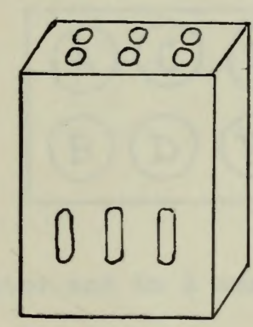
Stock solutions of the indicators were made up by preparing usually a 0.04 per cent solution with alcoholic water.

Color charts are available which show the color changes of these indicators for each 0.2 unit change in pH. To determine the pH value of an unknown solution, therefore, one has only to take in a test tube a portion of the solution to be tested, add a given amount of indicator (0.5 cc of indicator solution to 10 cc. of unknown solution) and compare the result with the color chart. While this method is satisfactory with clear and colorless solutions it can not be used with those that are turbid or have color which would mask the color of the indicator.

For turbid and colored solutions, color

standards are used with a device known as the color comparator. The color standards are made up from buffered solutions of definite pH value to which is added a given amount of indicator (0.5 cc of indicator solution to 10cc of the buffered solution). These standard solutions may then be preserved as permanent standards by introducing into a test tube, closing with a rubber stopper and then dipping the end in parafin to insure sealing. If desired a specially prepared tube with a constriction may be used. When the standard solution has been placed in the tube, the constriction is heated in a flame and drawn out, thereby sealing the tube. Pyrex glass tubes should be used. Probably the most satisfactory method would be to purchase the permanent standards and indicator solutions already prepared. The determinations of this investigation were done with such a set purchased from La Motte Chemical Products Company.

The color comparator[3] is a block of wood about five inches high by three inches wide and two inches thick in which are bored perpendicularly three pairs of holes as illustrated.

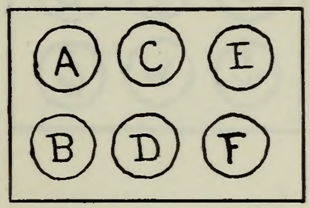


Near the base of the holes three slots are made horizontally so that it is possible to look through each pair of holes. By an ingenious arrangement of tubes in the comparator a high degree of accuracy of pH determination is possible even with turbid or colored solutions. The procedure is as follows:

Introduce into each of three test tubes 10 cc. of the solution to be tested and place

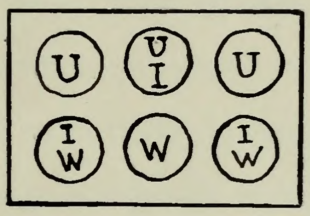
(3) The ABC of pH Control, La Motte Chemical Products Co. Eighth edition, p.13

them in holes marked A, C, E. To the middle tube C, add 0.5 cc. of indicator solution and mix thoroughly. In the hole marked D place a tube



of distilled water and in B and F put color standards differing by 0.2 pH, for example 3.4 and 3.6. Now look through the three pairs of tubes toward a source of light, preferable daylight. If neither of the outside pairs of tubes matches in color that of the central pair, change the color standards until a match is obtained or until the color of the central pair lies between the colors of the pairs on either side. If the color of the central pair matches that of a pair on either side the pH of the unknown is the same as that of the color standard used, for example 3.4. If the color of the central pair lies between the colors on either side, for example between 3.4 and 3.6 then the pH of the unknown is taken as 3.5.

From the accompanying diagram it will be seen that in looking through the three pairs of



tubes in the comparator we are in each case looking through the same combination: indicator, water, and unknown solution, thereby eliminating any effect of color or turbidity.

This method of colorimetric determination is highly satisfactory if the color of the unknown is not too deep. In this case it may be possible to dilute with distilled water to diminish the intensity of the color. If the unknown is naturally buffered, as is the case with fruit juice; dilution does not change the pH.

SECTION II

CONSTITUENTS OF A JELLY

[illegible]

[illegible]

Acid

The ideal fruit juice for jelly making would contain acid, pectin, and sugar in proper proportions. Since this ideal is not found it is necessary to add in different instances varying amounts of each of these constituents. The common acids used are citric and tartaric although malic and lactic acids are used to some extent. The use of the proper amount of acid has been found to improve the texture of the jelly, but not the flavor. Tartaric acid produces a firmer jelly while malic is second, and citric third in this quality. Phosphoric acid is used in the very cheapest grades of imitation jelly.

The optimum pH value(1) of a fruit juice solution for jelly making is between 3.0 and 3.55. At pH values higher than this, jelly does not form,

(1) Report on the Application of LaMotte pH Control to Food Industries: LaMotte Chemical Products Co. p.7

while below pH 3 the jelly becomes weaker and syneresis occurs. When the solution is adjusted to within these limits, maximum yield and best texture are obtained.

Pectin

Pectin is a carbohydrate of complex structure.[2] It is found as pectocellulose in the cellular tissue of many fruits and vegetables from which it can be extracted with hot water. If the extraction is subsequently treated with alcohol, the pectin will be precipitated and can be filtered and dried. Pectin is a reversible colloid, that is, it can be dissolved, reprecipitated, dried and redissolved without changing its characteristics.

Pectin is also precipitated in a concentrated sugar solution in the presence of the proper proportion of acid. During the process of boiling the

(2) Communication from The Source Research Bureau.

fruit juice a fine and even distribution of the pectin is secured which, upon cooling, precipitates in a sponge-like mass and sets the whole solution to a jelly. The higher the concentration of pectin, the less sugar is required. Above a certain maximum concentration, however, excess pectin seems to be inactive. The optimum concentration of pectin is 1.5 percent of the finished product. While pectin in excess of this amount is not active, it does not detract from the palatability of the jelly.[3] A prolific source of pectin is the inner rind of oranges and lemons from which it is easily extracted. Detailed procedure of its extraction will be given later in this paper. Since pectin is precipitated in a concentrated sugar solution it is necessary to provide this condition.

(3) Singh, L. A Study of the Relation of Pectin and Acidity in Jelly Making. J. Ind. Eng. Chem., 14, 710-711 (1922)

Sugar

Jellies may be made without adding sugar if the juice is boiled down until the concentration of natural fruit sugar is sufficient, but the product is tough and unpalatable. It is much more economical and satisfactory to add cane sugar or beet sugar to the fruit juice until the proper proportion is reached, which is about 65 percent of the weight of the finished product. If too much sugar is added, a soft syrupy jelly is formed. The most common cause of failure in jelly making is an overproportion of sugar to pectin.

SECTION III

EXPERIMENTS WITH CERTAIN FRUIT JUICES

General Procedure

In carrying out the following experiments with seven different fruit juices the same general procedure was followed in each case. The fruit was cleaned, and if large was cut into convenient size to facilitate boiling. A slight amount of water was added, and the fruit was boiled in an aluminum or agate kettle until soft. This process brings about the extraction of the juice and pectin from the solid mass of fruit.

The boiled fruit was then strained through flannel and the pulp discarded.

The juice was tested for pectin content by adding 2 cc. of 95 percent alcohol to 1 cc. of the juice. The formation of an abundant gelatinous precipitate indicates presence of pectin. A rough quantitative determination of pectin is obtained by this means. If sufficient pectin for jelly formation is present the gelatinous precipitate will occupy nearly the whole volume of the test solutions used.

When the fruit juice showed a lack of sufficient pectin it was added in the form of powdered pectin purchased from the Eastman Kodak Company, Rochester, N. Y. Varying amounts were tried in order to demonstrate that no advantage is gained in adding an excess of pectin.

Following the pectin test the pH value of the fruit juice was determined by the colorimetric method as described on pages 5-10 of this paper. If the pH value was higher than 3.55, citric acid solution was added and the pH redetermined until found to be lower than 3.55.

Varying percentages of sugar were used in order to determine which sugar concentration gave the best results. In each case the final weight of each sample of jelly was 100 gms.

For boiling and weighing the samples, a convenient arrangement is as follows:

Set up a burner and support with wire gauze. Take a 600 cc. beaker and counter-balance with weights on a platform balance placed adjacent to the burner. Add weights equivalent to the amount

of sugar which it is desired to add, for instance, 65 gms. Pour into the beaker the sugar which is necessary to counter-balance the weights just added. If it is necessary to add pectin it should be added at this time and thoroughly stirred in with the sugar. Then add more weights so that the total is 105 gms. more than the weight of the beaker. Pour into the beaker fruit juice to counter-balance the weights just added.

Stir the sugar and juice with a glass rod, put on burner and bring to a boil. Remove 5 gms. from the weights on the balance so that the total is now just 100 gms. more than the weight of the beaker. When the sugar and juice have boiled from one-half to one minute, transfer to the balance. If the weight is just 100 gms. in excess of the weight of the beaker pour into a small jelly jar and set aside; if not, bring to a boil again and reweigh until proper weight is reached.

The foregoing procedure was used in these experiments. The jelly jars were covered and comparisons made from time to time in regard to the quality of jelly formed.

of water which is [illegible]

[illegible]

water. [illegible]

when the [illegible]

[illegible] gms. [illegible]

[illegible]

[illegible]

the [illegible]

Fruit Juices Used and Results Obtained

Investigations were carried on with the juice of apple, plum, raspberry, tomato, pear, peach, and blueberry. This selection was made because it was known to contain some fruits which readily formed jelly and some which did not.

The juice was extracted from four pounds of apples and concentrated to about 750 cc. The alcohol test for pectin was applied and showed sufficient pectin for jelly formation. The pH determination gave a value of 3.4 which is well within the accepted range of favorable hydrogen-ion concentration. Since both pectin and acid content were satisfactory the only variable factor in this case was sugar concentration. Three samples were prepared containing respectively 75 percent. 65 percent, 40 percent sugar. The first sample, 75 percent sugar, gave a sticky, exceedingly viscous product, not a good jelly. The second, 65 percent sugar, gave an excellent jelly; firm, holding its shape when cut, yet quivering when the dish was shaken. This is the

test by which the excellency of the jelly was determined. The third sample, 40 percent sugar, gave no jelly at all, but remained a thin syrup.

The same procedure was followed with plums. The juice was extracted, tested for pectin and found to contain sufficient of that ingredient for jelly formation. The pH determination revealed a value of 3.2. Four samples were prepared containing respectively 70 percent, 60 percent, 50 percent, 40 percent sugar. The first gave a very stiff jelly; the second, a jelly of excellent quality; the third, a soft jelly; the fourth did not form jelly.

Raspberries produced an excellent jelly of delightful aroma. The juice was extracted and the pectin test revealed the presence of sufficient pectin. Due to the deep color of the raspberry juice, it was necessary to dilute before the determination of pH. Reasonable dilution of fruit juices does not change their pH since they are highly buffered. The pH determination of the diluted raspberry juice gave a value of 3.4. Again

the pectin and acid content were favorable to jelly formation so the only variable factor was the sugar concentration. Three samples were prepared containing respectively 70 percent, 60 percent, 40 percent sugar. The first and second gave jelly of excellent quality while the third did not form jelly.

Several attempts were made to secure a good jelly from tomato juice but no uniform success was attained. The juice was extracted from three pounds of tomatoes and concentrated to 250 cc. This was done to secure a stronger tomato flavor which was found to be weakened in samples to which citric acid was added. The pectin test revealed the absence of pectin and the pH determination showed a value of 4.1. The factors do not lie within the accepted limits but a sample was prepared containing 65 percent sugar (which is the optimum concentration). This set to a stiff, somewhat granular mass, not a good jelly.

Several samples were prepared from juice which was adjusted to pH 3.3 by the addition of

citric acid solution. In each case 1.5 gms. of powdered pectin was added and the sugar concentration varied as follows: 70 percent, 60 percent, 50 percent. The first, 70 percent sugar, formed a soft jelly; the second was of better consistency but developed mold; the third produced a good jelly but also a heavy mold.

Another trial in which the pH was adjusted to 3.5 gave somewhat similar results. With a pectin concentration of 1.5 percent, and sugar concentration of 60 percent, a stiff jelly was formed. With the same concentration of pectin, but 40 percent sugar, no jelly formed. With 0.75 percent pectin and 60 percent sugar a better quality of jelly was obtained.

In any case the quality of the jelly was not equal to that of the apple, plum, or raspberry.

Efforts to produce good jelly from the juice of pears were quite disappointing. The juice extracted from four pounds of pears was concentrated to about 500 cc. The alcohol test revealed the presence of pectin. The pH was found to be 3.9.

A sample prepared with 65 percent sugar and the juice as found, did not produce jelly.

The juice was adjusted to 3.5 by the addition of citric acid solution. A sample prepared from the adjusted juice with 70 percent sugar and no additional pectin gave a soft jelly. Upon standing several weeks many beautiful sugar crystals formed in the jelly as was also the case in other samples of pear and peach jelly. Another sample prepared from the adjusted pear juice, but containing 60 percent sugar and 1 percent pectin, gave a jelly of fair quality.

Several trials with pear juice adjusted to pH 3.2 by addition of citric acid solution and with varying concentrations of sugar produced a soft jelly. At 40 percent sugar concentration no jelly formed.

In addition to the fact that the pear does not produce jelly of good consistency, its mild flavor does not produce a really palatable jelly.

Four pounds of peaches were boiled and the extracted juice eoncentrated to 500 cc. The test

for pectin showed some pectin present but apparently deficient for good jelly formation. When tested for pH the value found was 3.6. A sample prepared with 65 percent sugar and the juice as found yielded a very soft jelly.

The juice was adjusted to pH 3.3 by the addition of citric acid solution. Two samples prepared from the adjusted peach juice and containing respectively 70 percent and 65 percent sugar with no additional pectin yielded a soft jelly. One similar sample but with 60 percent sugar yielded a very soft jelly. Two other samples prepared from the adjusted juice and containing respectively 65 percent and 60 percent sugar but with 0.5 percent pectin added gave a fair jelly. Two more samples similar to the preceding two but with 1 percent pectin added, yielded excellent jelly. Practically all of the peach jelly samples contained sugar crystals after two weeks except those with a sugar concentration of 60 percent which developed mold.

The results of trials with blueberries were

quite gratifying. The juice extracted from one quart of blueberries was concentrated to 100 cc. The alcohol test shows the presence of pectin but not as abundantly as in the apple. Again, because of the deep color it was necessary to dilute the juice before proceding with the colorimetric determination of the pH. However, because of its highly buffered state, dilution does not affect the pH which was found to be 3.5. Several samples were prepared. The first with no additional pectin and with 60 percent sugar yielded an excellent jelly. The second and third, each with 60 percent sugar but 1.5 percent and 0.75 percent pectin added respectively, gave a stiff jelly. A sample with 70 percent sugar and 1.5 percent pectin added gave a stiff jelly which produced crystals.

Summary of Results

From the foregoing investigations we must conclude that the proper concentration of three factors: pectin, hydrogen-ion, and sugar, is important in the production of a good quality of jelly. If any one of these is deficient, a total or partial failure will result. The best jelly is formed when the concentration of pectin equals 1.5 percent of the weight of the finished product, and the pH of the fruit juice lies between 3 and 3.5, and when the sugar concentration is 60-65 percent of the weight of the finished product. When the sugar content is 70 percent or more of the total weight a thick syrupy, sticky mass is produced. At less than 50 percent sugar the jelly is very soft; while at 40 percent sugar concentration, jelly does not form at all.

If the pectin content is less than 1.5 percent of the total weight, the jelly will be soft. With decreasing pectin content the stiffness of the jelly decreases for the setting of the jelly is due to the precipitation of pectin in a solu-

Summary of Results

From the foregoing investigations we must conclude that the proper concentration of three factors: pectin, hydrogen-ion, and sugar, is essential to the production of a good quality of jelly. If any one of these is deficient, a total or partial failure will result. The data would indicate that the concentration of pectin should be 1.0 percent of the weight of the finished product, and the pH of the fruit juice lies between [illegible] and 3.0; and that the sugar concentration is 65 percent of the weight of the finished product. When the sugar content is 70 percent or more of the total weight, with syrup, a syrupy jelly is produced. At less than 60 percent sugar the jelly is very soft, while at 50 percent sugar concentration, jelly does not form at all.

If the pectin content is less than 1.0 percent of the total weight, the jelly will be soft. With decreasing pectin content the stiffness of the jelly decreases for the rigidity of the jelly is due to the precipitation of pectin in a gel-

tion of the proper sugar concentration and in the presence of hydrogen-ions. Excess of pectin above 1.5 percent does not improve the quality of the jelly and can not be said to destroy it. Apparently excess pectin is inactive.

A variation on either side of the optimum pH results in a lowering of the quality of jelly. At pH 3.9 no jelly forms. If the fruit juice naturally does not contain sufficient hydrogen-ion and it is necessary to add acid to bring it to the proper value, there is danger of injuring or masking the distinctive flavor of the fruit juice. This was found to be the case in regard to tomatoes and pears.

We may conclude then, that while it is possible to produce jelly of good consistency when proper adjustment is made of the lacking factors, yet the best jelly is produced from those fruit juices which have naturally most nearly the ideal conditions.

that of the grapes alone, especially when used in the presence of [illegible]. Addition of pectin above 1.5 percent does not improve the quality of the jelly and may act to make it [illegible]. [illegible] results in [illegible].

A [illegible] on either side of the optimum pH results in a lowering of the quality of jelly. At [illegible] the jelly forms. [illegible] jelly [illegible] and it is necessary to add acid to bring it to the proper value. [illegible] a degree of [illegible] the [illegible] of the fruit juice. This was found to [illegible] improved by [illegible] and [illegible].

In [illegible] it is possible to produce jelly of good [illegible] in both [illegible] and the best jelly is produced from [illegible] juices which have naturally [illegible] the [illegible] [illegible].

Table Showing pH Values of Fruit Juices

	pH3.2	pH3.3	pH3.4	pH3.5	pH3.6	pH3.7	pH3.8	pH3.9	pH4.0	pH4.1
Apple			*							
Plum	*									
Raspberry			*							
Tomato										*
Pear								*		
Peach					*					
Blueberry				*						

With proper sugar content apple, plum, raspberry and blueberry produced excellent jelly without addition of acid. When sufficent pectin and acid were added to tomato and peach juice, a jelly of good consistency was obtained, but with pear juice only a soft jelly waa obtained.

Table Showing Pectin Content of Fruit Juices

Name of fruit	Amount of pectin
Apple	sufficient
Plum	sufficient
Raspberry	sufficient
Tomato	none
Pear	some
Peach	some
Blueberry	sufficient

With proper sugar content, apple, plum, raspberry, and blueberry produced excellent jelly without addition of pectin. When sufficient acid and pectin were added to tomato and peach juice, a jelly of good consistency was obtained, but with pear juice only a soft jelly was obtained. It will be observed that those fruits which contain sufficient pectin for jelly formation also have a pH value within the favorable limits.

Table Showing Change of Texture

Apple	no change
Plum	little change, few crystals in sample of highest sugar content
Raspberry	little change, few crystals in sample of highest sugar content
Tomato	crystals formed in samples of high sugar content
Pear	abundant crystallization in samples of high sugar content
Peach	some crystals in samples of high sugar content
Blueberry	little change, few crystals in sample of highest sugar content

Crystals are found in samples having an over-proportion of sugar. They may also be caused by insufficient cooking. Mention has been made in several cases of the formation of molds. Such formations have no significance in the present experiment as no effort was made to prevent the growth of molds. A universal practice is to pour melted paraffin over the hot jelly immediately after it is poured into the jar. This protective layer excludes dust and mold spores.

SECTION IV

PROCEDURES FOR LABORATORY EXPERIMENTS

Water Jelly

Purpose of the experiment:

To show how the formation of jelly is affected by varying the concentrations of acid, sugar, and pectin, and to determine which concentrations give best results.

Materials needed:

Powdered pectin, citric acid, sugar, sodium hydroxide solution (10 percent).

Procedure:

(1)a To 100 cc. of water add sufficient citric acid solution (dissolve 1 gm. of the acid in 100 gms. of water) or sodium hydroxide solution to bring it to a pH of approximately 6. The pH is determined by taking in a test tube 10 cc. of the solution and adding 0.5 cc. of a 0.04 percent solution of Bromcresol Purple or Chlorphenol Red. Compare with color standards in a block comparator. Into a 600 cc. beaker weigh out 65 gms. of sugar and 1.5 gms. of powdered pectin. Mix well and dissolve in 40 cc. of the acid solution which has been

adjusted to pH 6. Boil the solution until the weight is 100 gms. Do not allow it to boil over. Pour into a small beaker and set aside for 24 hours.

(1)b Prepare for use in this and in subsequent sections of this experiment 300 cc. of water to which has been added sufficient citric acid solution to adjust the pH to 3.2. Use 0.5cc. of a 0.04 percent solution of Brom phenol Blue as an indicator. Repeat the procedure of (1)a except use 40 cc. of the solution adjusted to pH 3.2.

(1)c To 100 cc. of water add sufficient citric acid solution to bring the pH to 2.6. Use 0.5 cc. of Meta cresol Purple as an indicator. Repeat the procedure of (1)a except use 40 cc of the solution adjusted to pH 2.6

(2)a Into a 600 cc. beaker weigh out 75 gms. of sugar and 1.5 gms. of powdered pectin. Mix well and dissolve in 30 cc. of the pH 3.2 solution prepared in (1)b. Boil the solution until the weight is 100 gms. Pour into a small beaker and set aside for 24 hours.

(2)b Repeat (2)a with the same amount of pectin, but use 65 gms. of sugar and 40 cc. of the pH 3.2 solution.

(2)c Repeat (2)a with the same amount of pectin but use 40 gms. of sugar and 65 cc. of the pH 3.2 solution.

(3)a Into a 600 cc. beaker weigh out 65 gms. of sugar and 2.5 gms. of powdered pectin. Mix well and dissolve in 40 cc. of the pH 3.2 solution prepared in (1)b. Boil the solution until the weight is 100 gms. Pour into a small beaker and set aside for 24 hours.

(3)b Repeat (3)a with the same amount of sugar and acid solution but use 1.5 gms. of pectin.

(3)c Repeat (3)a with the same amount of sugar and acid solution but use 0.5 gm. of pectin.

Cover all samples to prevent evaporation and compare at the end of 24 hours.

Did any sample fail to form jelly?

At which pH was the best jelly formed?

At which sugar concentration was the best jelly formed?

At which pectin concentration was the best jelly formed?

Apple Jelly

Purpose of the experiment:

To determine how much, if any, acid should be added to the juice of apple to produce the best jelly; and to show the effect of varying the acid and sugar content.

Materials needed:

Two pounds of unripe apples, citric acid, sugar, sodium hydroxide (20 percent).

Procedure:

Quarter 2 lbs. of unripe apples, nearly cover with water and boil until soft. Strain through cloth and evaporate the juice to 500 cc. Test for presence of pectin by adding 2 cc. of alcohol to 1 cc. of the juice. If an abundant gelatinous precipitate forms, sufficient pectin is present for the formation of jelly. Determine the pH of the solution by the use of the color standards and the color comparator. If the pH is between 3 and 3.55 it is favorable to jelly formation. If

the pH does not lie within these limits add a small amount of citric acid and redetermine the pH.

(1)a Into a 600 cc. beaker weigh out 75 gms. of sugar and add 30 gms. of the fruit juice. Boil until the weight is 100 gms. Pour into a small beaker and set aside for 24 hours.

(1)b Repeat (1)a weighing out 65 gms. of sugar and adding 40 gms. of the fruit juice.

(1)c Repeat (1)a weighing out 40 gms. of sugar and adding 65 gms. of the fruit juice.

(2)a To 100 gms. of the fruit juice add 10 gms. of citric acid crystals. When dissolved determine the pH using Meta Cresol Purple as an indicator. Into a 600 cc. beaker weigh out 65 gms. of sugar and add 40 gms. of the acidified fruit juice. Boil until the weight is 100 gms. Pour into a small beaker and set aside for 24 hours.

(2)b To 100 gms. of the fruit juice add 10 drops of 20 percent solution of sodium hydroxide. Determine the pH using Brom Cresol Green as an indicator. Into a 600 cc. beaker weigh out 65 gms. of sugar and add 40 gms. of the alkalized fruit

juice. Boil until the weight is 100 gms. Pour into a small beaker and set aside for 24 hours.

Cover all samples to prevent evaporation and compare at the end of 24 hours.

Did any sample fail to form jelly?

At which pH was the best jelly formed?

At which sugar concentration was the best jelly formed?

Tomato Jelly

Purpose of the experiment:

To determine how much, if any, acid, pectin, and sugar should be added to tomato juice to produce the best jelly.

Materials needed:

Four pounds of ripe tomatoes, powdered pectin, citric acid, sugar.

Procedure:

To four pounds of ripe tomatoes add a little water and boil until very soft. Strain through a cloth and evaporate the juice to 500 cc. Test for presence of pectin by adding 2 cc. of alcohol to 1 cc. of the juice. An abundant gelatinous precipitate indicates sufficient pectin for jelly formation. If no precipitate forms, pectin must be added. Determine the pH of the solution by the use of color standards and the color comparator. If the pH is between 3 and 3.55 it is favorable to jelly formation.

Pectin Jelly

Purpose of the experiment:

To determine how much, if any, acid, pectin, and sugar should be added to fruit juice to produce the best jelly.

Materials needed:

Four quarts of [illegible], granulated sugar, [illegible] pectin, [illegible].

Procedure:

To four quarts of ripe [illegible] add [illegible] and [illegible] every [illegible]. Strain through a cloth and [illegible] the juice [illegible]. Test for presence of pectin by adding [illegible] of [illegible]. If [illegible], an [illegible] indicates sufficient pectin for jelly formation. If no precipitate forms, pectin must be added. Determine the pH of the solution by the use of color standards and the color comparator. If the pH is between 3 and 3.35 it is favorable to jelly formation.

(1)a Into a 600 cc. beaker weigh out 65 gms. of sugar and 1.5 gms. of powdered pectin. Mix well and add 40 gms. of the tomato juice. Boil until the weight is 100 gms. Pour into a small beaker and set aside for 24 hours.

(1)b By the addition of citric acid adjust the pH of the tomato juice to within 3 and 3.55. Repeat (1)a but use 40 gms. of the adjusted tomato juice.

(1)c By the addition of citric acid adjust the pH of the tomato juice to 2.6 or below. Repeat (1)a but use 40 gms. of the acidified tomato juice.

For the remainder of this experiment the tomato juice should be adjusted to within pH 3 and 3.55.

(2)a Into a 600 cc. beaker weigh out 65 gms. of sugar and 2.5 gms. of powdered pectin. Mix well and add 40 gms. of the adjusted tomato juice. Boil until the weight is 100 gms. Pour into a small beaker and set aside for 24 hours.

(2)b Conditions identical with (1)b and need not be repeated.

(2)c Repeat (2)a but use 0.5 gms. of pectin.

(3)a Into a 600 cc. beaker weigh out 75 gms. of sugar and 1.5 gms. of powdered pectin. Mix well and add 30 gms. of adjusted tomato juice. Boil until the weight is 100 gms. Pour into a small beaker and set aside for 24 hours.

(3)b Conditions identical with (1)b and need not be repeated.

(3)c Repeat (3)a but use 40 gms. of sugar and 65 gms. of juice.

Cover all samples to prevent evaporation and compare at the end of 24 hours.

Did any sample fail to form jelly?
At which pH was the best jelly formed?
Which pectin content is most favorable?
At which sugar concentration was the best jelly formed?

Preparation of Pectin

Purpose of the experiment:

To prepare powdered pectin from orange peel.

Materials needed:

Rinds of four oranges, alcohol, ether.

Procedure:

Peel 4 oranges and cut the peel into narrow strips. Shave off the outer colored layer. Cut the inner white portion into small pieces, place in a beaker, cover with water and boil for ten minutes. The pectin is soluble in hot water and by this means is extracted from the orange peel. Filter through cloth and to filtrate add an equal amount of 95 percent alcohol. The abundant gelatinous precipitate is pectin. Filter through cheese cloth or flannel. Wash the residue once with ether. Filter and dry on porcelain plate. When dry gather together and pulverize in a mortar.

BIBLIOGRAPHY

Bogue, R. H. The Theory and Application of
Colloidal Behavior
McGraw-Hill Book Company, Inc. 1924
Vol. I pp. 377-499
Vol. II pp 605-626

Bronson, B. S. Nutrition and Food Chemistry
John Wiley & Sons, Inc. 1930
pp. 402-417

Clark, W. M. The Determination of Hydrogen Ions
Williams & Wilkins Co. 1928 Third edition
pp. 1-229

Goldthwaite, N. E. Contribution on the chemistry
and physics of jelly-making
J. Ind. Eng. Chem. 1, 333-340 (1909)

Goldthwaite, N. E. Contribution on jelly making
(second paper)
J. Ind. Eng. Chem. 2, 457-462 (1910)

Morrow, C. A. Biochemical Laboratory Methods
John Wiley & Sons, Inc. 1927
pp. 236, 237

Singh, L. A study of the relation of pectin
and acidity in jelly making
J. Ind. Eng. Chem. 14, 710-711 (1922)

The ABC of pH Control
LaMotte Chemical Products Co. (1932)
Eighth edition
pp. 1-24